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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Steel Mill
Lubrication Problems

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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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Steel Mill Lubrication Problems

LUBRICANTS in steel mills must function under a greater variety of probable adverse conditions than in any other industry. These conditions must be considered not only when the lubricants are being selected but also when they are applied. It is well, therefore, to review the objectionable effects they may have upon lubrication of mill machinery, i. e.

1. Water often is sprayed on equipment under high pressure. Since it may be worked into the bearings, it will not only contaminate the lubricant but also have a tendency to wash it from the parts it is supposed to lubricate. In a circulating system, this can be very serious. Consequently one of the conspicuous requirements for a circulating oil is that it must separate readily from water.

2. High temperature conditions are often encountered where red hot steel is being processed. This heat is transmitted through machinery being lubricated or is radiated to the operating parts at close range. To meet these conditions greases for roll neck or table roll bearings must be heat resistant. This is measured by their ability to hold their consistency.

3. The same lubricant is often called on to be soft and easily pumpable through centralized system lines at temperatures below zero degrees Fahrenheit and for distances of several hundred feet.

4. Lubricants are required to lubricate mills running at very high speeds where strip is being rolled at faster than a mile a minute.

5. Oils and greases are also required to lubricate machines running at slow speeds but under extremely high pressures.

Steel mill machinery by the nature of the work for which it is designed, is very heavy; at the same time it must give precision performance especially in rolling where gauges of small fractions of an inch must be maintained. For these reasons the steel industry has become one of the most exacting consumers of special type lubricants made for specific equipment.

Most of the lubricating problems are different from those encountered in other industries. Some of the problems have existed for decades and there seems to be no solution, but operators have learned to live with them while trying incessantly to improve operating conditions.

It is the purpose of this article to discuss a few of the more prominent steel mill lubricating problems and to point out some of the methods used in various mills in overcoming the difficulties. Since the ideas may be applied equally as well to heavy duty machinery other than in the steel mill, it is believed that operators and lubrication engineers in general will benefit by the experience in the steel industry.

Water and Mill Scale Contamination Of Hot Strip Mill Bearing Oil Systems

The circulating oil (2000 to 2500 SSU viscosity at 100°F) used for lubrication of backup roll bearings of hot strip mills often becomes contaminated with water and mill scale, forming stubborn emulsions which are difficult to break. Water from high pressure descaling sprays and roll cooling water leaks past the seals and carries with it fine iron oxide particles from the strip. This material can be so fine that it passes through pressure filters and remains suspended in the oil.

In many hot strip mill circulating oiling systems emulsions begin to form within two or three days after the mill goes into operation on a batch of oil. Emulsions usually show a brownish oil discoloration at first but as the amount of water increases they gradually turn to a pale yellow.

It has been observed that as soon as the emulsions appear, less water drops out in the settling tank and the water content of the oil climbs rapidly. The circulating pump seems to "homogenize" the water with the oil and stabilizes the emulsions. If the tank of emulsified oil can be removed from service soon enough the emulsions are more easily broken and water can be removed by heating to 170 or 180°F. and holding the oil at rest for a few days. The longer the tank remains in service the more stable the emulsions become and the more heat is required to break them.

It is important therefore that water and mill scale be removed as soon as possible after they enter the bearing oil system if troublesome emulsions are to be avoided.

Courtesy of The Farval Corporation

Figure 1—The run-off end of a "United" 46" blooming mill showing fittings and piping for the Farval grease lubricating system. The conditions of water and mill scale which prevail on such mills are clearly shown, and illustrate why protection against lubricant contamination is so important.

Solution:

A. Since contamination of circulating oils is a serious problem, great efforts are being made in most mills to keep water and scale out, or if they get in, to remove them as soon as possible. Some of the procedures being followed are outlined below:

1. Bearing seals are being continually improved by bearing manufacturers and by maintenance personnel.

2. Damage to seals is being carefully avoided in the roll shops during inspection and installation.

3. Water legs are installed in the oil return line from each roll stand enabling operators to detect worn or damaged seals before contamination becomes serious.

4. Elaborate reclamation systems, consisting of two storage tanks, heaters, centrifuges and filters, are installed in most mills to remove contaminating materials but it is seldom that the procedure followed by any two mills is the same. For instance there is a difference of opinion among operators regarding the advantages of the centrifugal purifier, one or more of which are usually supplied as standard equipment with modern oil circulating systems.

5. Breaking of tight emulsions is sometimes quite difficult and the problem is often complicated by the fact that all types of cooling water are involved, some consisting of raw river water having a slight acid reaction and others containing various chemicals. The following meth-

Courtesy of Trabon Engineering Corp.

Figure 2—A view down the finishing train of a hot strip mill showing water conditions, and steam coming off the table rolls. With steel passing through such mills at a speed sometimes greater than 2000 feet per minute, it is obvious that the Trabon grease lubrication system is a valued asset in assuring against contamination of lubricant, and insuring continuous production.

ods of breaking emulsions have been found quite effective:

(a) Two storage tanks are used alternately; one containing clean oil is placed in operation while the other containing contaminated oil from previous week's run is being cleaned.

(b) Used oil is heated up to 180°F. in the spare tank for several hours. After standing for a few days, free water settles to the bottom and can be drawn off. This will remove most of the water and the remainder can be separated by passing the oil through an auxiliary heater (maintained at 200°F.) just before passing into a centrifuge.

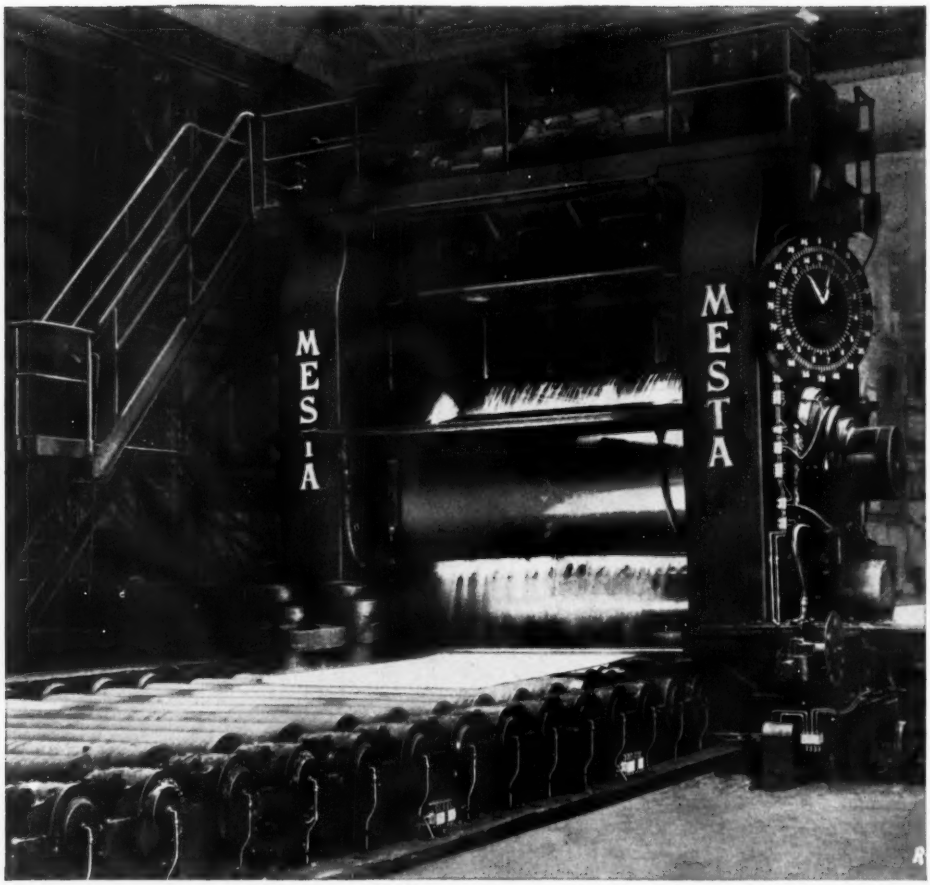
(c) Centrifugal purifiers are operated in several ways depending on the preference of individual operators.

(1) In some cases the centrifuge is started when the oil system begins operation, and runs continuously.

(2) In other cases a centrifuge is only used after water appears in the oil and it is then operated only until water content drops to a desired point.

(3) To maintain effective purification it is necessary to use a centrifuge with sufficient capacity to keep the oil in clean condition even if the seals leak badly.

(d) Emulsion breakers are frequently used to hasten the batch treatment and to break stubborn emulsions. Considerable care must be exercised to use only the proper amount (usually around 0.10%) and to get it thoroughly mixed with contaminated oil. An emulsion breaker should be added slowly in the oil return line to the settling tank or at the pump suction while the mill is operating, approximately 8 hours prior to the change to the spare tank of oil. The oil should then be heated to 180° or 190°F. and allowed to settle 24 to 48 hours, after which water should be drawn off.



Courtesy of The Farval Corporation

Figure 3—Twenty-four hour operation of a modern plate mill allows no time for shut-downs for lubrication, or for repair due to faulty lubrication; hence the value of the Farval centralized grease lubrication system. In plate mill service the lubricant is exposed to water and mill scale, unless the lubricating system is properly sealed. The Farval system affords this protection.

(e) It has been found that the slower speed hot strip mills are sometimes operated for short periods on oil containing 5 to 25% water without noticeable harmful effect on bearings. In faster cold roll mills operating around 5000 ft. per minute, or higher, it is desirable to keep the water content well below 0.5%. In the latter mills operating temperatures usually rise rapidly as the amount of water in the oil increases.

6. Some operators will not use centrifuges, preferring to batch-treat the oil by heating and allowing to settle for 10 days or more. Settling tanks should be of large capacity in order to facilitate settling of water and mill scale while the oil is in service. Two of the prerequisites of efficient gravity settling are slow movement of oil through the tank and sufficient heat to reduce the viscosity of the oil. Many settling tanks contain no baffles while others have only one near the oil inlet.

(a) With this design, the warm oil from the bearings (being lighter than the cool oil in the tank) enters at one end and flows directly to the float suction at the opposite end of the tank in a matter of a few seconds, therefore, only a small percentage of the available oil in the system is recirculated. The short period of time in the tank does not permit proper settling nor does the incoming oil mix with the bulk of the oil in the settling tank.

(b) The use of baffles in the settling tank reduces the velocity and allows the incoming oil to remain in the tank for a longer period

of settling. The temperature at which oil in the operating tank is kept will depend on the cooler capacity because it is essential that the oil returning to the bearings be maintained at 100 to 105°F. as usually recommended by the bearing manufacturers.

B. In addition to the above methods of cleaning up oil-water emulsions, other mechanical methods are also being investigated and it is possible that much speedier and more efficient procedure will be developed.

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Water and Mill Scale Contamination Of Cold Strip Mill Bearing Oil Systems

The circulating oils (1500 to 2500 SSU at 100°F.) used for lubrication of backup roll bearings of cold strip mills also get contaminated with water and mill scale but to a lesser extent than in hot strip mills, due to the fact that water for high pressure descaling is not used.

Solution:

The problem of separating water and scale from the oil is usually handled in the same manner as listed under the preceding discussion on contamination of hot strip mill bearing oil systems.

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Sticking of Backup Roll Bearings

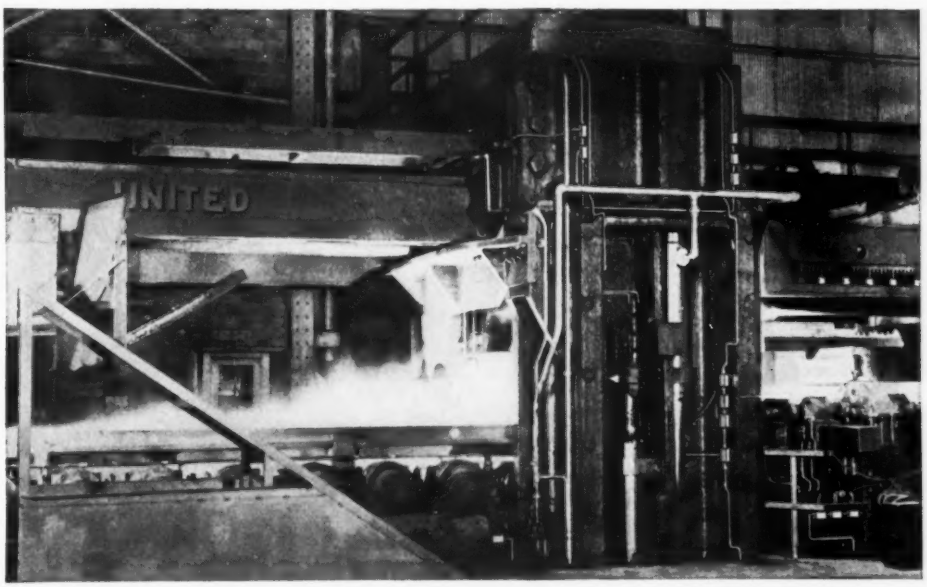
Cold reduction mills and temper mills having oil film type backup roll bearings are often very difficult to start after a shut-down because of sticking of the backup roll neck bearings. These plain bearings are usually lubricated with straight mineral oils having a viscosity of 1500 to 2500 SSU at 100°F. Sticking is usually caused by oil being entirely squeezed away from the bearing surface while in static condition and the bearing is under such a heavy load that metal to metal contact takes place.

Power applied through work rolls is transmitted to the backup rolls by friction and when the backup rolls are stuck the slippage of the work rolls often wears a flat place on the backup rolls. This makes it necessary to regrind these rolls.

Sticking also often results in wiped bearings. When such failure occurs relining of bearings is a costly operation.

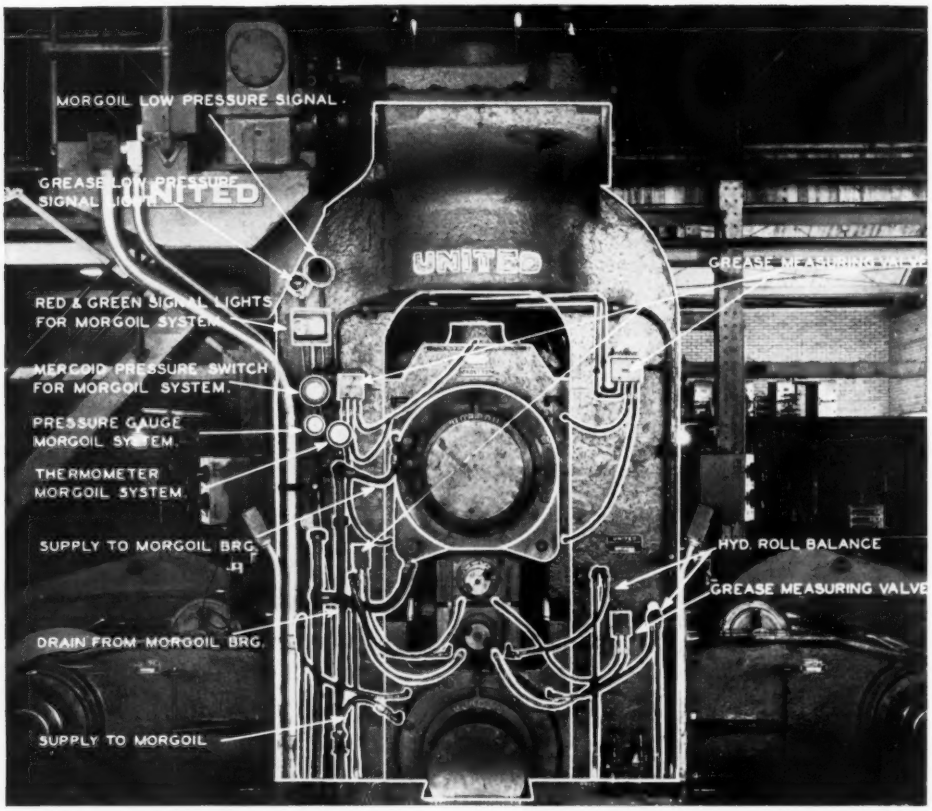
Solution:

Many mills have eliminated this type of difficulty by using circulating oils containing oiliness or E. P. additives, or both. The additives provide sufficient lubrication under boundary conditions to enable mills to start easily. The number of bearing failures and flattened rolls are thereby reduced to a minimum.



Courtesy of Trabon Engineering Corp.

Figure 4—A hydraulic slab shear with the hot steel in the shear ready for cutting. Visualize the effect which this heat along with contaminating foreign matter can have upon the lubricant for the shear parts unless it is handled by a suitable lubricating system. Here again protection against contamination (by Trabon) is as important as selection of a high quality grease designed to withstand heat conditions.



Courtesy of United Engineering & Foundry Company

Figure 5—End view of a United mill showing details of the lubricating systems serving the grease-lubricated roller bearings on the work rolls, and the oil-lubricated MORGOIL back-up roll bearings.

Bearing manufacturers are not in accord with the use of additives that might in any way interfere with rapid separation of water from the circulating oil. For this reason many desirable additives can not be used because they have an adverse effect on the demulsibility of the oil. There are, however, a few additives, which from the standpoint of laboratory and plant operation tests, have no adverse effect on water separation.

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Wear on Reduction Gear Sets:

Reduction gear sets are usually lubricated with mild type EP gear lubricants having viscosities at 210°F. ranging from 50 to 1000 seconds. These lubricants are highly resistant to oxidation and are designed to withstand heavy duty operation.

The gear sets are usually lubricated by several methods such as:

1. Dipping of the teeth into a sump containing lubricant.
2. Gear lubricant sprayed on at the point of meshing.
3. Cut-back type leaded E. P. lubricants sprayed on to the gear teeth.

Excessive wear of gears and pinions in enclosed reduction gear sets is often encountered in steel mill rolling operations. This is particularly true in equipment which is being operated at heavier loads and higher speeds than those for which it was originally designed. Sometimes the gears are badly worn and gouged while at other times the teeth have deeply pitted and flaked out areas.

Solution:

When difficulty of this kind is encountered the following steps should be taken:

1. Check for misalignment of gears themselves and check for worn bearings which may be causing misalignment.

2. Check gear metal for proper hardness. Excessive wear is often due to use of gear metal softer than specified. Incidentally, in some mills hardened pinions are used in gear reduction sets.
3. Use lead soap E. P. gear lubricants; they usually will minimize excessive wear. They also have a certain cushioning effect and the E. P. additives assist in providing smoother operation. If gears are heavily overloaded, approaching the limit of metal strength, it is very difficult to overcome wear completely and it is only a matter of time before gear teeth will become worn and gouged to a point where replacement is necessary. Excessive pounding under heavy loading will also have a tendency to produce heavy pitting and flaking. E. P. lubricants will help to lessen this effect but can not eliminate it entirely, since it results from metal fatigue.

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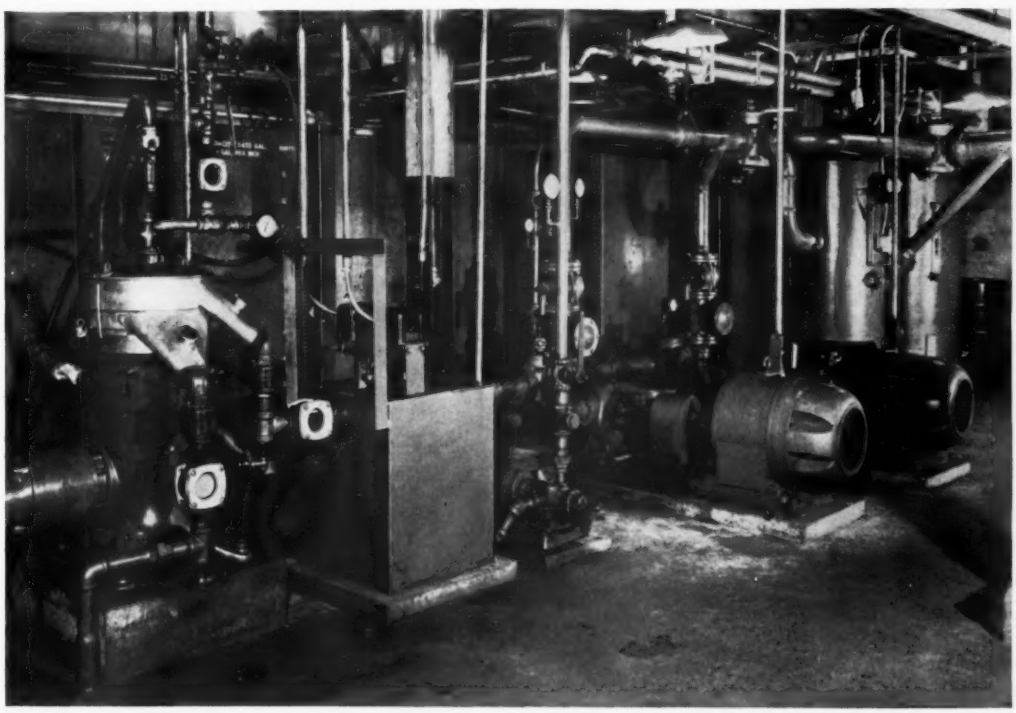
Water and Mill Scale Contamination of Enclosed Gears on Plate Mill Tables, Blooming Mill Tables and Vertical Edgers

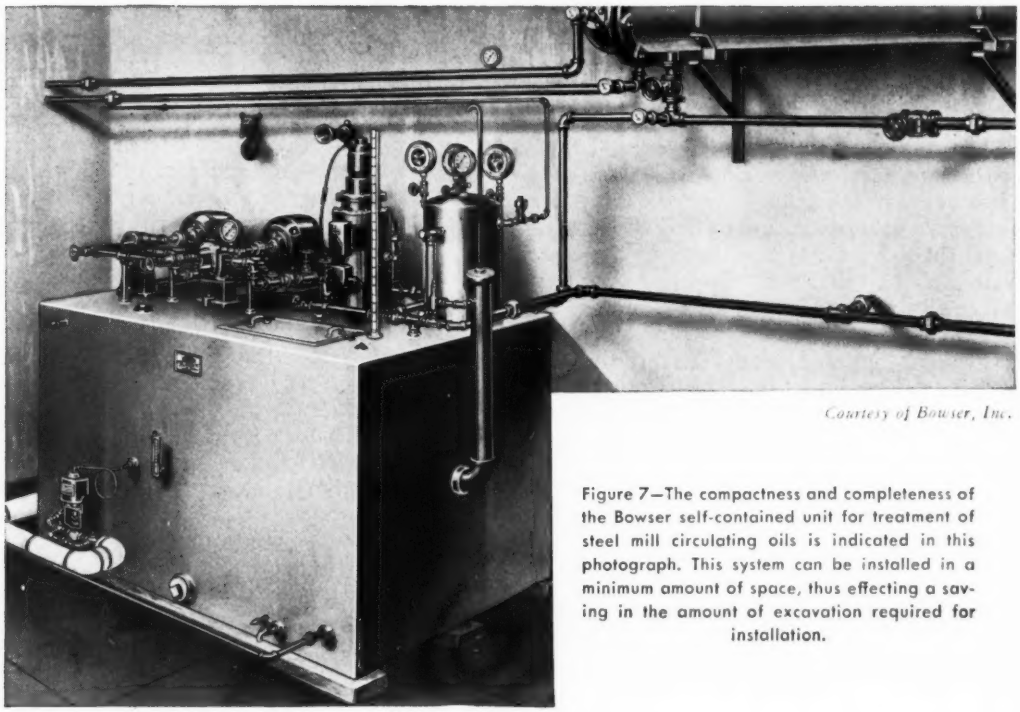
Enclosed type gears on front and back tables of plate and blooming mills have always presented a very discouraging lubrication problem due to the contamination of the gear lubricant with water and mill scale which are forced into the gear housing by high pressure descaling sprays usually mounted on the roll stand. Old mills which provided only bath lubrication for the table roller mitre gears required a 1500 to 1800 SSU at 100°F. viscosity oil. As water filled the gear housing it floated out much of the lubricant and completely emulsified the remainder. Mill scale mixing with the emulsified oil produced a most effective lapping compound playing havoc with the gears.

Some of the early oil circulating systems installed for the tables also lubricated the screwdown drives of the roll stands and other equipment thus making it necessary to use the same high viscosity lubricant on the table gears as was required for the screwdown drives. This exposed all equipment to the water and mill scale taken into the table gear housing so it was soon necessary to install a separate system for the table gears. Since the oil basement was not designed to accommodate another oil system, the one provided was usually a makeshift affair entirely inadequate for the job — consisting chiefly of a small single compartment settling tank and a circulating pump.



Courtesy of The DeLaval Separator Co.

Figure 6—To insure continued circulation of properly cleaned oil it is well to provide suitable means for purification. The DeLaval custom-built system involving centrifugal treatment is well suited for this type of service. In this connection it is important that the system not only provides lubrication but also has ample capacity for cooling the oil.



Courtesy of Bowser, Inc.

Figure 7—The compactness and completeness of the Bowser self-contained unit for treatment of steel mill circulating oils is indicated in this photograph. This system can be installed in a minimum amount of space, thus effecting a saving in the amount of excavation required for installation.

Later systems provided an oil inlet at one end of the table housing with the oil outlet at the other end but high enough to permit the gears to dip in a bath of oil. When water and mill scale filled the gear housing to the outlet level the incoming oil flowed through the housing on top of a bath of water providing very little lubrication for the gears which dipped into water and mill scale.

Solution:

The following steps have been found to be effective in solving these difficulties:

1. Install spray pipes to flood each set of mitre gears continuously with extreme pressure lubricant having an approximate viscosity of 750 seconds at 100°F.

2. Place the oil outlet in the bottom of the gear housing to enable the water and mill scale to be flushed into a two compartment settling tank of adequate size.

3. Make the following changes and adjustments on the settling tank:

   (a) Equip each compartment of the tank with two baffles to reduce the velocity of the oil through the tank and thus permit better settling.

   (b) Attach a removable fine mesh basket strainer to the oil return line entering the settling tank. This will remove large quantities of mill scale.

   (c) Install a magnetic filter to remove fine mill scale which usually passes through the pressure filter.

   (d) Install steam coils in the settling tank at a steep angle to allow more uniform heating of the oil and to permit easier cleaning of the tank.

4. Follow the procedure outlined below for operating the settling tank:

   (a) Alternate the compartments of the settling tank every ten days or two weeks.

   (b) During batch treatment of the oil a temperature of 170 to 180°F. is usually sufficient to break normal emulsions. For breaking stubborn emulsions it may be necessary to heat the oil to 200°F.

   (c) Agitate the oil thoroughly while heat is being applied to reduce localized hot spots

which would promote oxidation. Agitation may be accomplished by use of mechanical stirrers or by blowing with compressed air at temperature below 150°F.

There is always the possibility of excessive oxidation, however, when air is blown through oil at high temperatures. Cool dry air passing through warm oil partially dehydrates the oil and helps to break up emulsions due to the ability of warm air to hold more moisture than cold air.

When air agitation is used the saturated air passes out through the manholes or it may be discharged outside of the oil basement by means of "fog fans" or small suction blowers mounted on top of the settling tank.

Those who use air for agitation feel that more damage is done to the oil by localized heating than by the use of air for the short time required to bring the oil up to a proper temperature for batch treatment; they feel that the advantages of air agitation more than offset the disadvantages.

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Water and Mill Scale Contamination of Open Gears on Plate Mill Tables, Blooming Mill Tables and Vertical Edgers

Open type table gears are usually lubricated at suitable intervals with heavy adhesive petroleum products. Water and mill scale contamination do not present too great a problem since there is no gear case involved to retain them. The chief problem in lubricating these gears is to maintain an adequate coating of lubricant at all times.

Solution:

The following methods of lubrication are being used at present:

1. Preheated heavy adhesive lubricant is applied to gears by paddle or it is poured on with a dipper. This method is not satisfactory since most of the grease is thrown off the gears and wasted during operation.
2. Spray type lubricants containing diluent are now replacing many of the heavier lubricants. Portable spray guns are used and gears are sprayed once a shift or at other suitable intervals depending on operating conditions. Spray type products, in spite of higher initial cost, are more economical than the heavy type lubricant because there is no waste in application and no throwing off in operation.

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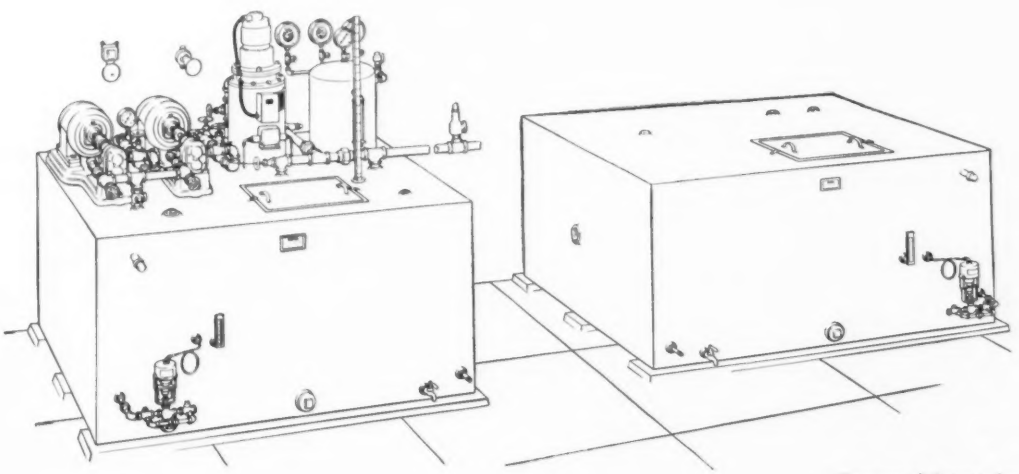
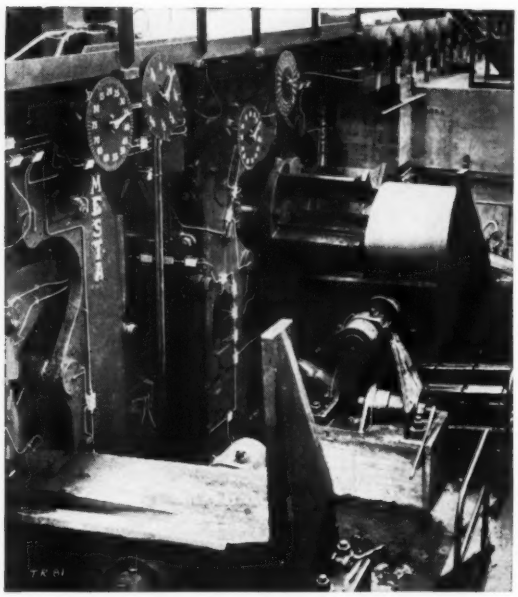
Mill Screw Lubrication

Main mill screws and screw nuts on mills with a great amount of screw travel, such as in blooming mills and slab mills, wear out fast if not lubri-



Courtesy of Bowser, Inc.

Figure 8—The Bowser dual tank system also is well suited for treatment of steel mill circulating oils. By using two receiving tanks the oil can be pumped or returned to either tank at will. Such an installation is particularly suited for service where considerable quantities of sludge or water are present in the oil. Here the foreign matter in one batch of oil can be precipitated out, while the clean oil in the other tank is being circulated through the system.



Courtesy of Trabon Engineering Corp.

Figure 9—Showing details of the Trabon system of piping and fittings applied to a strip steel coiler. The coiler (or reel as it is called in cold mills) comprises a rotating member surrounded by segments containing two guide rolls each. These rolls are carried on roller bearings provided for grease lubrication. Protection of these bearings is important due to the heat which is still retained by the strip, and the water which sometimes deluges the coil during winding. The Trabon system of centralized lubrication is well suited to this type of service, and can be planned so that the piping is protected against the flapping end of the strip as the winding of each coil is completed.

cated frequently. Fine mill dust in the atmosphere collects on the screws and acts as an abrasive.

Conventional practice on older type mills is to lubricate by pouring a high viscosity cylinder oil around the top of the screw and let it work its way down the threads.

Solution:

More recent practice, however, is to lubricate the screws by a feed line off the circulating system which is used to lubricate the screw down drives. A high viscosity lead soap E.P. gear type lubricant is usually used, having an viscosity at 210°F of around 400-500 SSU. A measured quantity is applied to screws and splines at frequent intervals. This type of lubrication results in a cleaner condition around the mill, lower consumption due to less oil waste, and much longer screw and nut life.

In some mills the screws are covered with a telescopic type of shield to keep out dust.

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Plain Roll Neck Bearings — Grease Lubricated

Grease lubricated plain roll neck bearings usually operate under high pressures and are exposed to bad water conditions. The old method of lubrication was by hand packing the bearings with a semi-solid consistency grease. In order to lubricate these bearings properly the grease must adhere well to wet roll necks and resist being washed off by water. These bearings often have short bearing life due to this inadequate method of lubrication.

Solution:

Many mills are now being equipped with pressure systems which utilize a soft grease which is easily pumpable. Grease is supplied through a groove in the bearing and a small amount is pumped in at frequent intervals.

Some operators recommend graphited greases, since graphite seems to fill in the rough surfaces and also repels water; it thus prolongs bearing life. The use of this type of grease, however, has a disadvantage because the graphite has a tendency to wear out metering valves on the lubricating systems. Poor metering valve life appears to be the lesser of two evils.

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Universal Spindle Couplings

The lubrication of the bronze slipper in universal spindle couplings on rolling mill equipment has always presented a difficult problem chiefly because when spindles need lubrication they are in motion and centrifugal force has a tendency to throw off the lubricant.

The bronze slippers wear excessively and have to be replaced often if not sufficiently lubricated.

Solution:

This problem has never been completely solved but the following partly satisfactory methods are being used at the present time:

1. Adhesive types of E.P. lubricants are applied during the time of shutdown. These have less tendency than straight mineral oils to throw off during operation.

2. Adhesive type greases of #0 or #1 consistency are applied through pressure fittings at shutdown periods.

3. On some high speed mills cylinder oils are dripped continuously on the spindles during operation. This is not too efficient since most of

the oil is thrown off before it gets a chance to lubricate.

4. On certain slower speed mills a chain type oiler has been quite successful using a fairly light oil as lubricant.

5. Recently a new type of enclosed spindle coupling has been put on the market. It is equipped for "automatic built in" lubrication using a #0 grade of E.P. Grease.

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Lubrication of Blast Furnace Tops

Lubrication of bell and distributor systems on blast furnace tops has always been a difficult problem because it is necessary for operators to climb up to the top of the furnace and apply grease from a hand pressure gun. This could be somewhat hazardous because of poisonous gases coming from the stack. For this reason two men always were sent in case there was any emergency.

Solution:

New type blast furnaces are now equipped with automatic greasing systems. A grease pump is usually located in the hoist room and grease is piped to the lubrication points at the top of the furnace. Usually a #O grade grease is used in winter to provide easy handling and a #1 grade in summer. The grease in addition to lubricating the various parts of the mechanisms also serves to purge out the dirt which accumulates in the bearings.

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Lubrication of Vaughn Wire Drawing Benches

These benches consist of a series of motors each of which connects through a worm gear to a drum around which wire is wrapped. The bearing metals are steel on bronze. On old type benches a straight mineral oil, having a viscosity of 900-1000 SSU. at 100°F. is generally used. With this type of oil many operators experience development of excessive heat along with resultant thickening of the lubricant.

Solution:

Experience in the field has shown that a lead soap E.P. type of gear oil gives greatly improved lubrication. Operating temperatures are lowered and the excessive thickening of the lubricant is minimized to a great extent.

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Air Compressor Lubrication

Air compressors should be lubricated with me-

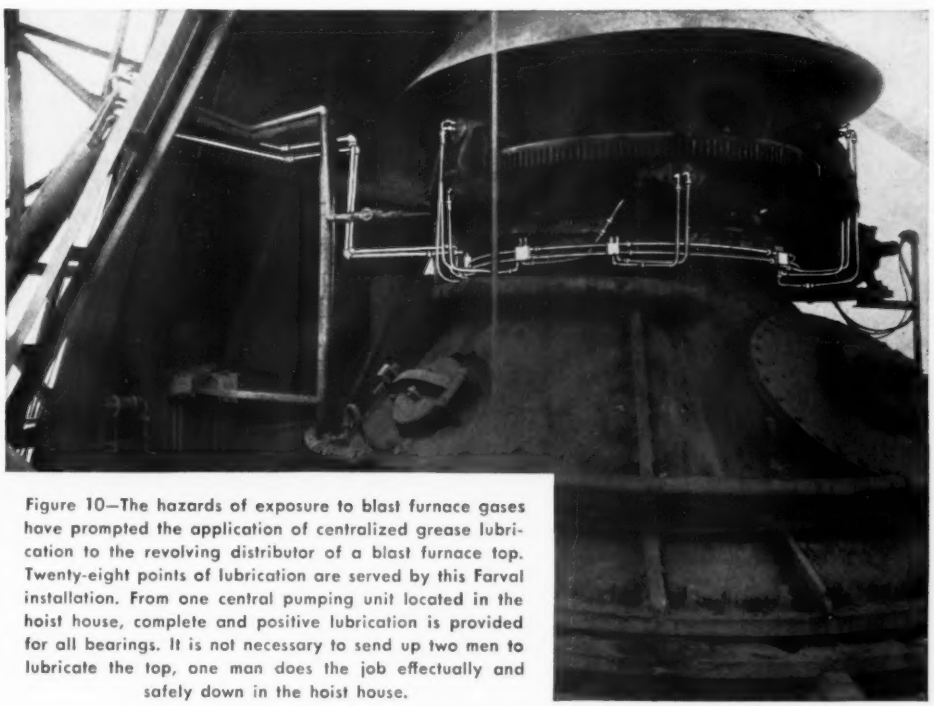

Figure 10—The hazards of exposure to blast furnace gases have prompted the application of centralized grease lubrication to the revolving distributor of a blast furnace top. Twenty-eight points of lubrication are served by this Farval installation. From one central pumping unit located in the hoist house, complete and positive lubrication is provided for all bearings. It is not necessary to send up two men to lubricate the top, one man does the job effectually and safely down in the hoist house.

Courtesy of The Farval Corporation

dium viscosity highly refined mineral oils which are resistant to oxidation and which can lubricate over a wide range of operating conditions.

Air compressor operation often presents difficulties such as:

1. Fires and explosions in the lines.
2. Rusting in lines due to presence of water which condenses from the air.
3. Damage to tools caused by rust particles coming through with the air.
4. Plugging of vane guides in rotary type compressors.

Solution:

After a considerable amount of investigation it has been found that the choice of lubricant or method of application will eliminate most of these difficulties.

1. Fires and explosions usually are caused by excessive oil feed. Oil carbonizes and eventually plugs up the lines allowing pressure to build up to a dangerous point. Cutting the oil feed down to a minimum will solve this problem.
2. Rusting in lines can be eliminated by using a rust inhibited oil as compressor lubricant. Some of the oil gets into the lines protecting them from rusting. This also will minimize damage to tools due to rust in the air lines.
3. Plugging of vane guides in rotary compressors can be stopped by using a detergent type compressor oil which keeps the vanes and guides clean.

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Wire Cable Lubrication

Lubrication of wire cables on blast furnace skip hoists presents a problem in many mills. Some operators think it is best to lubricate such cables with thick, sticky products. These provide good lubrication but they have several disadvantages.

1. The cables may pick up large quantities of dirt and sand due to the thick lubricant coating. This can eventually cause excessive wear and become a source of potential cable failure.
2. Such lubricants being cohesive have a tendency to "throw off" during operation and also peel off when cable runs over the sheaves especially in cold weather.

Solution:

It has been found that spray type E.P. lead soap gear lubricants containing a thinner give greatly improved performance. They are usually applied by hand spray on the cable at the drum with a permanent type spray system located near the top of the furnace to coat that portion of the cable not reaching the drum. This type of lubricant has the following advantages:

1. The lubricant layer is comparatively thin so it does not pick up much dirt and sand.
2. Due to the adhesiveness of the thin layer it does not throw off or peel off.
3. It is more economical since there is less waste.

★ ★ ★

Conclusions

In view of the tremendous tonnage of steel processed and the multiplicity of lubrication problems involved, it is generally agreed that steel mill operators and lubrication personnel have shown remarkable ingenuity in handling very difficult situations.

The sympathetic interest of the petroleum industry is noteworthy. Its research laboratories and technical service personnel have been untiring in studying the solutions of the problems of the mill people and in developing lubricants which can be relied upon most dependably. If this review of some of the problems, and the suggested solutions helps to keep machinery on the line and steel tonnage coming off at peak production, we will hope we have contributed in a small way towards national security.

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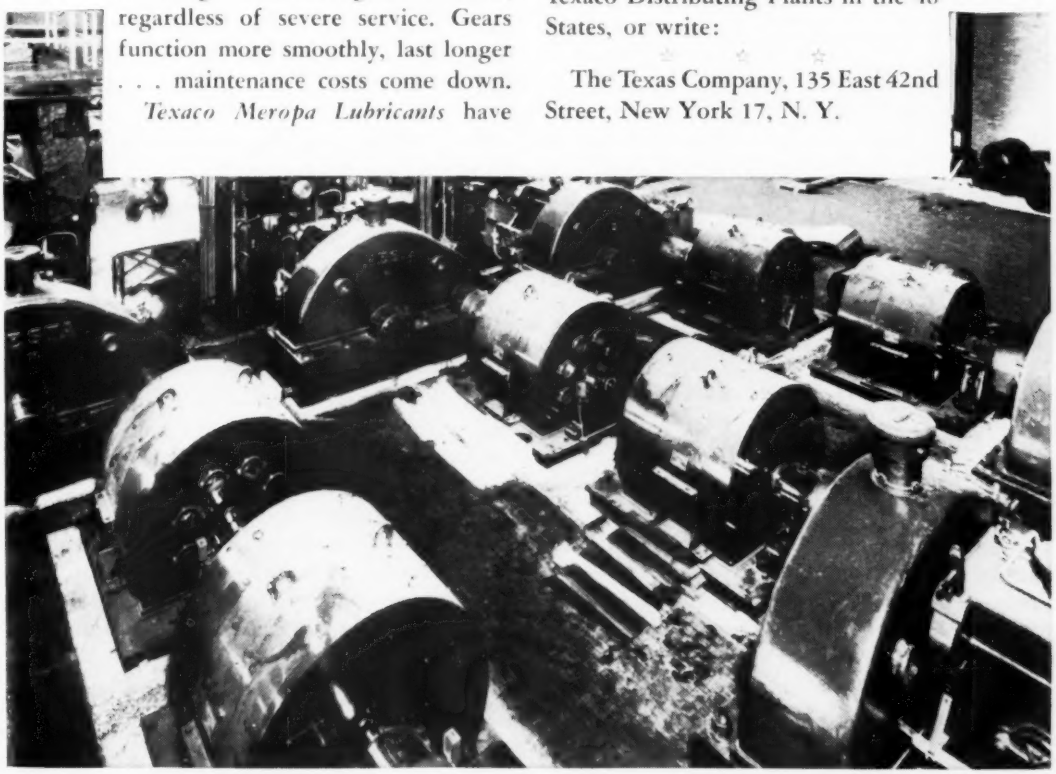

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